# Adaptive Thresholding Techniques

EECS5330
Image Analysis and Computer Vision
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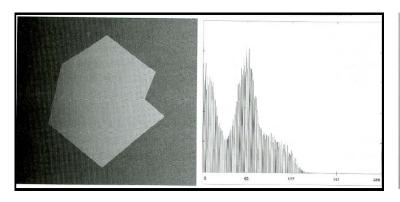
### Overview

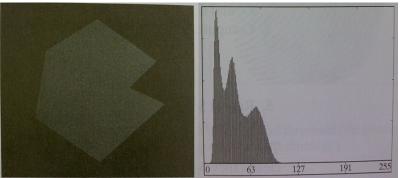
#### **Image Binarization**

- Global Thresholding
  - o applied to the entire image
  - o global thresholding has difficulty with images that have:
    - changes in illumination
    - scanning errrors
    - low resolution
    - complex documents(mixed text and graphics)
- Variable Threholding
  - any method that uses more than one threshold for the image
- Adaptive Thresholding
  - uses a local neighborhood to calculate the threshold for each pixel

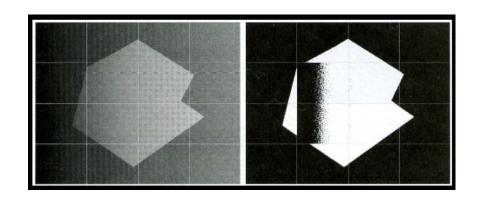
# Binarization Using Thresholding

- Basics
  - Global thresholding.





Adaptive thresholding



- Otsu's Algorithm
  - Select Threshold level T
  - 2 Sets of pixels S₀, S₀
  - Weight & variance object & background
  - Variances: within-set between-set, total
  - Select Threshold for maximum between-set vs within-set ratio
- Niblack's Algorithm
  - Choose a square scanner
    - size: b x b
  - Apply thresholding within square

$$\begin{split} W_o &= \sum_{i=1}^T p(i) \, ; \ W_b = \sum_{i=T+1}^L p(i) \, ; \ W_b = 1 - W_o \\ \mu_0 &= \sum_{i=1}^T \frac{i p(i)}{W_0} \, ; \ \mu_b = \sum_{i=T+1}^L \frac{i p(i)}{W_b} \, ; \ \mu_T = W_0 \mu_0 + W_b \mu_b \\ \sigma_o^2 &= \sum_{i=1}^T \frac{(1 - \mu_o)^2 p(i)}{Wo} \, ; \ \sigma_b^2 = \sum_{i=T+1}^L \frac{(1 - \mu_b)^2 p(i)}{Wb} \end{split}$$

$$\sigma_W^2 = \omega_0 \sigma_0 + \omega_1 \sigma_1 \qquad \sigma_B^2 = \omega_0 (\mu_0 - \mu_T)^2 + \omega_1 (\mu_1 - \mu_T)^2$$

$$\sigma_T^2 = \sum_{i=1}^L (i - \mu_T)^2 p(i) \qquad \eta = \max_{1 \le T \le L} \frac{\sigma_B^2}{\sigma_W^2}.$$

$$m(x,y) = \frac{1}{b^2} \sum_{j} \sum_{i} f(i,j)$$
  $\sigma^2(x,y) = \frac{1}{b^2} \sum_{j} \sum_{i} (m(x,y) - f(i,j))^2$ 

$$T(x,y) = m(x,y) + k * \sigma^{2}(x,y)$$

#### Bernsen's Method

- A classic method that others use for comparison
- Finds threshold of the center pixel, T(i,j), of a n x m set pixels by calculating the mean of the maximum and the minimum value of the pixels in the window
- $\circ$  T(i,j) = 0.5 \* {max[c(i + x, j + y)] + min[c(i + x, j + y)} where x,y iterate over all pixels in the window
- $\circ$  b(x,y) = 1 if [c(i,j) T(i,j)] > 0 0 otherwise

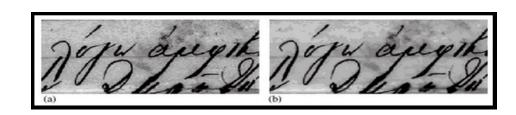




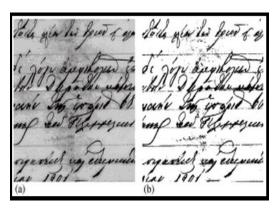
#### Sauvola Method

- a hybrid method that adapts the threshold window to either text or graphic types.
- divide the image into small windows and use TD to determine the type of threshold to use
- $\circ$  TD = [2P(i,j)-[P(i-1,j)+P(i,j-1)] over every p(i,j)
- o For graphics use:
  - calculate a weighting system based on local histograms
  - use weights to determine the threshold for each pixel
- For text use: (modified Niblack)
  - $T(i,j) = m(i,j) + \{1 + k[var(i,j) / (R 1)]\}$ 
    - R = the dynamic range of the standard deviation

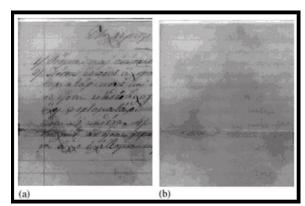
- Gato's Method
  - Wiener applied
     Smoothing background



 Binary image using Sauvola's alogrithm



 Background image select threshold d



- Apply Thresholding
  - T(i,j) = 1 for { backround(i,j) image(i,j) } > d

#### Comparison of Techniques

J. Sauvola, M. Pietikäinen / Pattern Recognition 33 (2000) 225-236

#### Result images and ranked benchmarking evaluation results

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Input image

Ground truth

Sauvola

Niblack

Bernsen

Eikvil

Parker

Sauvola	95.8 %
Niblack	89.9 %
Eikvil	82.1 %
Bernsen	78.6 %
Parker	38.4 %

#### Description of the BM event:

- -15 textual document images with various fonts and typefaces.
- Each document having implanted illumination.
- -The degree of illumination is varied (non-illuminated=>bad illumination).
- -The above visual results show 20% illumination factor applied to GT image map.

Fig. 12. Visual and numeric results on the comparison algorithms applied to illuminated, textual images.

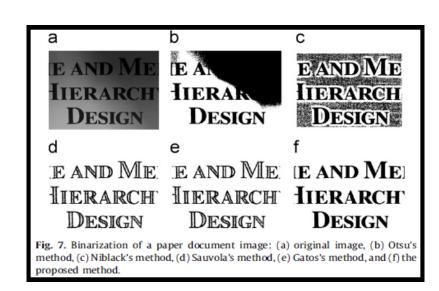
### A New Method

[Yu-Ting Pai, et. al.]

- Problems with current Adaptive Thresholding methods
  - Recursive → Time + Memory + Computation
- Fusion
  - Smoothing
  - Select box size
  - Segment Image
  - Threshold segments
  - Computational Complexity
    - M x N size, L levels, b block size

Otsu:  $MN+7L^2+5L-12$  Niblack:  $(4b^2+3)MN$ 

Fusion: N(M-1)



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